5   **DEVICE FOR CONVERTING LIGHT**

The present invention concerns a device for converting light
from, for example, a laser, VCSEL (Vertical cavity surface
emitting laser) or LED/-s to a plane of propagation
10   comprising a collimated or focused light emitter.

The device is adapted for, for example, usage for generating
a plane of light, which either can be totally flat or conical
in a desired degree upwards or downwards. Such devices are
15   used for example at construction works, road construction
work and the like.

Background art
20   This has previously been solved by means of a device with a
light source whose light beam has been angled by means of a
rotating prism or mirror, which rotates 360° so that the
rotating beam describes a plane of propagation around the
device.
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A problem with these known devices is that they require very
accurate manufacturing so that the rotating parts do not
angle the light beam incorrectly during the rotation.
Additionally, at least one motor is needed to rotate them.
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Another problem is that they are provided within four
windows, which lead to four corner pillars for the holding of
the windows, which blocks the propagation of the light plane.
An attempt to get away from the problem with rotating parts
35   and motors has been done in US 3820903. In that the rotating
parts have been replaced by a conical, reflecting prism which
deflects a laser beam 90° so that a plane is formed 360°
around the prism.

40   A problem connected with the use of a reflecting cone is that
the device becomes very sensitive to angle deviations of the
cone relative the incoming light beam since a small angle
deviation there is enlarged in the plane of propagation, see

Fig. 1b. The angle error will be doubled according to the law of reflection. A small angle error may at long distance give large position errors.

Summary of the invention

These problems are solved by means of a device according to claim 1. The advantage with this solution is that a double reflecting component is almost totally unsensitive to mounting errors. A rotationally symmetric double reflecting component works in analogy with a so called pentaprism. In a pentaprism, the angle between incoming and outgoing beam is fix irrespective the translation sideways or tilting. A body with two mutually fixedly connected reflecting surfaces with a mutual angle relation α deflects an incoming beam 2α, i.e. the double mutual angle relation of the reflecting surface, irrespective the incoming angle (Fig. 1b).

When the body is turned an angle β in the plane of propagation for the beams, the beam will be deflected 2β at the first reflection. This deflection is compensated at the reflection in the second surface, which also has been turned the same angle β. The reasoning may be repeated for a further pair of reflecting surfaces. The independence of the incoming angle for the deflection thus concerns mirror bodies with an arbitrary even number of reflecting surfaces, i.e. components with a reflection in each of an even number of surfaces, hereafter called double reflecting components.

Another advantage is that the need for any rotating parts or motors is eliminated. Additionally, the deflection of the light beam and the windows are combined in the same detail, namely the double reflecting component.

Preferably, means is provided in the path of the beam between the light emitter and the double reflecting component with which the incoming angle of the light towards the double reflecting component may be adjusted, which in turn affect the angle of the plane of propagation out of the double

reflecting component. It is of course a great advantage that
the one and same device in an easy way may be set to generate
a horizontal plane or a conical plane of propagation angled
in a desired angle (upwards or downwards).

This can be done in several possible ways. One way is to
position one or two axicons coaxially where at least one
axicon is displacebly mounted along one axis which coincides
with the centre axis of the double reflecting component. An
axial displacement of one axicon changes the size of the ring
in the common focal plane of the lenses. In such a way the
angle of the collimated beam cone is changed.

An axicon confers some image errors. These can be compensated
by the use of two axicons with cone angles of opposite signs.

Another way is to provide a zoom lens coaxially with the
double reflecting component. The size of the ring can then be
constant. The angle of the cone is changed during zooming
since the focal length of the zoom lens is changed.

Preferably the collimated emitter emits light in the form of
a ring or a portion or portions of a ring, for example, by
means of refractive or diffractive axicons or axicons of
Fresnel type. If a totally surrounding beaming plan is not
desired, also portion or portions of the double reflecting
component be blocked from light.

Another embodiment shows the use of an electrically driven
two-axes micro mechanical mirror. The collimated light hits
the mirror which is angled in such fashion that the light
beam describes the mantle of a cone, i.e. so that a ring is
drawn in the double reflecting component.

Short description of the drawings

Fig. 1 a+b shows a reflecting component according to known
            art and its problem.

Fig. 2 a+b   shows the function of a double reflecting
              component according to the invention.

Fig. 3   shows an arrangement of the invention according
              to a first embodiment for setting of a desired
              angle of the plane of propagation in a first
              position. The light image in the focal plane is
              shown underneath the Figure.

Fig. 4   shows the arrangement in Fig. 3 in a second
              position. The corresponding light image is shown
              underneath the Figure.

Fig. 5   shows an arrangement of the invention according
              to a second embodiment for setting of a desired
              angle of the plane of propagation in a first
              position. The light image is shown underneath the
              Figure.

Fig. 6   shows the arrangement in Fig. 5 in a second
              position. The corresponding light image is shown
              underneath the Figure.

Fig. 7   shows an arrangement of the invention according
              to a third embodiment for setting of a desired
              angle of the plane of propagation in a first
              position. The light image is shown underneath the
              Figure.

Fig. 8   shows the arrangement in Fig. 7 in a second
              position. The corresponding light image is shown
              underneath the Figure.

Fig. 9   shows an arrangement of the invention according
              to a fourth embodiment for setting of a desired
              angle of the plane of propagation in a first
              position. The light image is shown underneath the
              Figure.

Fig. 10   shows the arrangement in Fig. 7 with another
               setting which gives a partial light image.

Fig. 11   shows an example of how the beam path can go into
               a double reflecting component. After the focal
               plane only the central beams of the bunch of
               beams, so called main beams, are shown due to
               clarity.

Fig. 12   shows a first embodiment of the invention with a
               two-axes micromechanical mirror seen from the
               side.

Fig. 13   shows the embodiment of Fig 10 from above.

Fig. 14   shows a number of embodiments of the double
               reflecting component.

Fig. 15   shows a second embodiment of the invention with a
               two-axes micromechanical mirror seen from the
               side.

Fig. 16   shows the embodiment in Fig. 15 from above.

**Detailed description of preferred embodiments of the
invention**

Fig. 1a shows known art with a conical prism 1 which deflects
light beams 2 with 90°, which is emitted from an emitter 3
collimated by a focusing lens or a collimator 4. Fig. 1b
shows the influence of a erroneous mounting of the prism 1 in
Fig. 1a. An error angle α of the prism 1 gives an angle
deviation 2α for the beams 2.

In Fig. 2a an arrangement with a double reflecting component
5 according to the invention is shown. The beams 2 hit a
first reflecting surface 6 and are deflected with an angle γ.
The beams are then reflected by a second reflecting surface 7
and are deflected then a with an angle γ. The angle θ between

5   the incoming and outgoing beam 2 is fix irrespective
      translation sideways or tilting, see Fig. 2b.

      Of course, both of the reflections does not have to be of the
      same size, instead the double reflecting component 5 may be
10   designed so that the first surface reflects in a smaller
      angle and the second surface reflects in a larger angle or
      vice versa.

      In Fig. 2b the double reflecting component 5 is erroneously
15   mounted with an angle β in the plane of the drawing. On the
      right side of the drawing the beams 2 hit the first
      reflecting surface 6 and are deflected with an angle $\gamma + 2\beta$.
      Thereafter, the beams 2 are reflected in the second
      reflecting surface 7 and are deflected with an angle $\gamma - 2\beta$.
20   Thus, the angle between the incoming and outgoing beam 2
      become θ since the errors even each other out.

      On the left side of the Figure the beams 2 hit the first
      reflecting surface 6 and are deflected with the angle $\gamma - 2\beta$.
25   Thereafter the beams 2 are reflected in the second reflecting
      surface 7 and are deflected with an angle $\gamma + 2\beta$. Totally the
      angle between the incoming and outgoing beam 2 is also θ on
      this side.

30   Since the double reflecting component 5 is rotationally
      symmetric it will be a continuous transition of the erroneous
      deflection (2β and -2β, respectively) from the extreme
      position on the right side via no erroneous angle
      orthogonally to the plane of the drawing (i.e. the beam 2 is
35   deflected with γ in the first and the second surface) to the
      extreme position on the left side in the Figure (-2β and 2β,
      respectively) but the total angle between incoming and
      outgoing and will always be θ around the double reflecting
      component 5.

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      In Fig. 3 an arrangement according to a first embodiment for
      the possibility to change the angle of the plane of
      propagation from a double reflecting component (not shown in

this Figure) is shown. An emitter 3 emits light beams 2 which
are collimated in a focusing lens or collimator 4. Thereafter
the light beams enter into a movably mounted axicon 8, which
can be refractive, diffractive or of Fresnel type.

In a focal plane 10 the beams have joined each other and
formed a ring of light 11, see the image directly underneath
the arrangement. Preferably, the beam path in the middle
image is telecentric, i.e. the main beams are parallel with
the optical axis. With such an arrangement the resulting cone
angle will become unsensitive to small focusing errors
between the lenses. Thereafter is a second collimating lens
12 provided, which deflects the beams 2 to a leave pupil 13.
Preferably, the double reflecting component 5 is arranged so
that the leave pupil 13 ends up within the double reflecting
component 5. All comprising parts are arranged coaxially to
each other.

In Fig. 4 the same arrangement is shown as in Fig. 3 but the
axicon 8 have been displaced closer to the focusing lens or
collimator 4 along the common axis. In such a way a light
ring 11 is formed having a larger diameter in the focal plane
10, see the image underneath the arrangement. The light beams
2 will thereafter go further through the collimating lens 12
and there be refracted in a greater angle than at the shown
setting in Fig. 3.

The axicon may be interchangeable if so desired in order to
thus be able to change the size of the light ring in the
focal plane.

Thereby, the double reflecting component 5 will be hit by
light beams with another incoming angle than present
according to the setting in Fig. 3 having the result that the
plane of propagation from the double reflecting component 5
will have another angle than at the setting according to Fig
3.

5   In Fig. 5 an arrangement according to a second embodiment for
       the possibility of changing the angle of the plane of
       propagation from a double reflecting component (not shown in
       this Figure) is shown. An emitter 3 emits light beams 2 which
       are collimated in a focusing lens or collimator 4. Thereafter
10   the light beams enter a first fixedly mounted axicon 8, which
       may be refractive, diffractive or of Fresnel type, and
       further through a second movably mounted axicon 9 which also
       may be refractive, diffractive or of Fresnel type.

15   In a focal plane 10 the beams have converged and formed a
       ring of light 11, see the image directly underneath the
       arrangement. Preferably the beam path in the middle image is
       telecentric, i.e. the main beams are parallel to the optical
       axis. With such an arrangement the resulting cone angle is
20   unsensitive to small focusing errors between the lenses.
       Thereafter a second collimated lens 12 is provided which
       deflects the beams 2 to a leave pupil 13. Preferably the
       double reflecting component 5 is arranged so that the leave
       pupil 13 is within the double reflecting component 5. All
25   parts comprised are coaxially arranged to each other.

       In Fig. 6 the same arrangement as in Fig. 5 is shown but the
       second axicon 9 have been displaced away from the fixedly
       mounted axicon 8 along the common axis. In such a way a light
30   ring 11 is formed having a larger diameter in the focal plane
       10, see the image underneath the arrangement. The light beams
       2 thereafter run further through the collimating lens 12 and
       is refracted there with a greater angle than at the shown
       setting in Fig. 5.

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       Thus, the double reflecting component 5 is hit by light beams
       having another incoming angle than present in the setting in
       Fig. 7 giving the result that the plane of propagation from
       the double reflecting component 5 will have another angle
40   than at the setting according to Fig. 5.

       With the arrangement according to Figs. 3-6 the plane of
       propagation may be set from a determined angle downwards so

that a downwards angled conical plane of propagation is
formed via a flat horizontal plane of propagation (without
angle) to a determined angle upwards so that an upwards
angled conical plane of propagation is formed.

In Fig. 7 another arrangement is shown according to a third
embodiment for the possibility to be able to set the angle of
the plane of propagation of the beams 2 from the double
reflecting component 5. The arrangement comprises an emitter
3, collimator 4 and one or two fixed axicons 8, 9 for the
forming of the light image 11 in the focal plane 10, in this
case a circle, see the image underneath the arrangement.

Further, a zoom lens 14 is comprised with which the outgoing
angle of the beams 2 may be set. All parts comprised are
coaxially arranged. With the setting of the zoom lens the
outgoing angle of the beams are changed.

In Fig. 8 the zoom lens 14 has another setting so that the
outgoing angle of the beams 2 from the zoom lens 14 is
different. In such a way the incoming angle of the beams 2 to
the double reflecting component 5 may be set giving the
result that the angle of the plane of propagation may be set.

In Fig. 9 a further arrangement is shown according to the
invention. Also here the parts comprised are coaxically
arranged. The arrangement comprises an emitter 3, collimator
4 and a diffractive light image generator 15, which, for
example, provides three different rings 11 with different
diameters.

The rings may be distinguished from each other with different
patterns, such as shown underneath the arrangement, having a
inner dotted ring, a full middle ring and a broken line for
the outer ring or in any other way, such as different colours
of the light rings 11.

The beams 2 in the different light images 11 have different
diameters and hit a collimated lens 12, whereby they are

reflected in different angles so that they will have different incoming angles in the double reflecting component 5 and thus give differently angled plans of propagation from the double reflecting component 5.

For example, the middle light ring may give a flat horizontal plane of propagation and the two other light rings a downwards directed and an upwards directed, respectively, conical plane of propagation, for example, 1° upwards and downwards, respectively.

In Fig. 10 it is shown that partial beam images 11 also may be formed if desired by means of, for example, a diffractive component. This may also be obtained by masking the double reflecting component 5 so that the beams 2 will be stopped and the plane of propagation will not become totally surrounding.

In Fig. 11 it is shown an embodiment of the invention according to Fig. 5 where also the double reflecting component 5 is shown. The path of the beams 2 through the double reflecting component 5 is also shown. If three different light images 11 are present in the focal plane 10 they form three different planes of propagation 17.

If these planes in imagination are sketched 18 towards the centre axis they will meet in a central point 16. This central point operates as a conceived "hinge" or "hub" from which one or several planes of propagation 17 in imagination starts and may be inclined upwards or downward from there.

In Fig. 12 another embodiment of the invention is shown, which uses an electrically driven two-axes micro-mechanical mirror 20. A collimated light beam 2 from an emitter 3 hits the mirror 20, which is angled by means of electronics (not shown) so that the light beam 2 describes the mouth of a cone, i.e. that a ring is drawn in the double reflecting component 5.

5   A certain portion 22 of the light beam 2 is reflected in the
       bottom of the double reflecting component 5 and falls in on
       two photodiode arrays 21 provided orthogonally to each other,
       see Fig. 13. In such a way a feedback is provided so that
       adjustments may be done by means of electronics (not shown)
10   of the ring of light and the centering of the same.

       In Fig. 14 a number of different arcs are shown, as an
       example.

15   In Fig. 15 a second embodiment of the variant of the
       invention as in Fig. 12 is shown. There the possibility to
       use one or two axicons between the micromechanical mirror 20
       and the double reflecting component 5 is shown. It is also
       possible to instead use a zoom lens there in-between.